SWAMP
Surface Water Ambient Monitoring Program

FINAL Technical Report	2009

SWAMP Safe-to-Swim Study, Labor Day 2008

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SWAMP Safe-to-Swim Study, Labor Day 2008

FINAL October 2009

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REGIONAL WATER QUALITY CONTROL BOARD
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CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

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1.0 EXECUTIVE SUMMARY

On August 27, August 31, and September 3, 2008, staff from the Central Valley Regional Water Quality Control Board (Central Valley Water Board) conducted a region-wide water quality study of local swimming holes during a period of anticipated elevated recreation use, e.g. over a holiday weekend. The study consisted of sampling before, during, and after the 2008 Labor Day weekend, for general water quality parameters (specific conductivity, pH, and temperature) as well as *E. coli* as a pathogen indicator.

Twenty-one stakeholder groups throughout the Central Valley Region participated in the site selection process. Staff provided training, supplies and sample transportation to five stakeholder groups assisting with sample collection. Seven field crews from Central Valley Water Board were required for each sample collection date and all *E. coli* sample analyses were conducted at Central Valley Water Board's in-house laboratories.

Results show that 52 out of a total of 57 sites did not exceed the EPA's recommended full contact recreation limit for *E. coli* (235 MPN/100mL) on any of the three collection dates. Of the five sites with elevated levels, four sites in the Sacramento River Basin exceeded the EPA's recommended limit for *E. coli* on one or more of the collection dates. An additional site in the Sacramento River Basin had a duplicate Quality Assurance field sample exceed the EPA guideline. Four of these five sites exhibited the highest *E. coli* concentrations on the first day of the study, before the Labor Day weekend. Elevated *E. coli* concentrations prior to the highest level of human use indicate that factors other than human recreation likely dominate *E. coli* concentrations. Flow data and field measurements of temperature, specific conductivity (SC), and pH were variable between the 5 sites and it is unclear if these constituents had an effect on the *E. coli* concentrations. Based on information collected during this project, future-monitoring efforts in the Central Valley Region should consider:

- Pathogen identification studies to help characterize *E. coli* sources.
- *E. coli O157:H7* analysis to determine if the pathogenic *E.coli* is present.
- Analysis for other types of water-borne pathogens like *Cryptosporidium* and *Giardia*.
- Follow-up *E. coli* sampling at other times of the year to develop a more thorough analysis of water quality.

Summary data sheets are in Appendix 1 and also posted at:
http://www.waterboards.ca.gov/centralvalley/water_issues/water_quality_studies/surface_water_ambient_monitoring/swamp_recreational_use_2008/index.shtml

2.0 INTRODUCTION

During other water quality monitoring efforts, Central Valley Regional Water Quality Control Board (Central Valley Water Board) field staff have many times been asked by the public whether or not it is safe to swim in their local streams creeks and rivers. While extensive effort has been made to answer this question at coastal beaches (State Water Resources Control Board's Clean Beaches/Oceans Program, http://www.waterboards.ca.gov/water_issues/programs/beaches/beach_water_quality/index.shtml), little has been documented for inland water-ways.

The purpose of this study was to determine whether there was any indication that the beneficial use of full contact recreation was not being achieved in local swimming holes within the Central Valley during a period of anticipated high use. The indicator utilized was *E. coli* with the US EPA guideline for full contact recreation (235-MPN/100ml) as the benchmark. Sampling sites consisted of sites utilized by local stakeholders for contact recreation (specifically, swimming holes, defined as places in fresh, moving water, such as rivers, streams, creeks, springs, or similar natural bodies of water, which are large enough and deep enough for a person to swim in. This criterion excludes lakes and/or shallow stream sections). The survey was conducted before, during and after Labor Day weekend in 2008 (August 27 – September 3, 2008).

Sampling sites consisted of locations throughout the Central Valley Region including the American, Calaveras, Cosumnes, Feather, Kings, Merced, Mokelumne, Pit, Sacramento, San Joaquin, Stanislaus, Tuolumne and Yuba River Watersheds as well as a number of smaller creek watersheds. Many sites were identified as local swimming holes by the stakeholder groups.

Data was collected at each site for *E. coli,* total coliform, specific conductivity (SC), pH, and temperature. The original monitoring plan also called for additional samples to be analyzed for *Cryptosporidium, Giardia,* and *E. coli O157:H7*. However, the delayed state budget prevented the use of a contract laboratory for these analyses.

3.0 BACKGROUND

One of the purposes of the Surface Water Ambient Monitoring Program (SWAMP) is to evaluate whether there is any evidence that beneficial uses are not being protected. The Central Valley Regional Water Quality Control Board (Central Valley Water Board) Basin Plan identifies contact recreation as a beneficial use throughout the Region. Although the Basin Plan identifies a water quality objective that utilizes fecal coliform (not to exceed 400 MPN/100mL in a single sample), *E. coli* can also be utilized as an indicator for potential pathogens and is a subset of fecal coliform. The U.S. EPA has developed contact recreation guidelines for *E. coli,* and an Amendment to the Central Valley Basin

Plan is pending that would change the objective to terms of *E. coli.* Using *E. coli* as an indicator, this study developed a snapshot of the water quality in local swimming holes before, during and after a major holiday (August 27 – September 3, 2008).

In 2007, an initial screening study was conducted by SWAMP over the Labor Day holiday (Central Valley Water Board, 2009) to provide information on potential logistical constraints in conducting a broader valley wide survey. A number of recommendations came from the pilot study including the need to sample all locations at approximately the same time of day, ideally in the afternoon when people are more likely to swim. Special consideration was needed to ensure the maximum number of samples that could be processed by the Water Board Laboratories was not exceeded. The 24-hour hold time of the *E. coli* was an additional consideration in the design of this study. Based on the statewide SWAMP Quality Assurance Program Plan (State Water Resources Control Board, 2002), *E. coli* samples processed within 24-hrs of collection are valid results for assessment purposes but may not meet criteria required for regulation.

4.0 MONITORING OVERVIEW

Watershed organizations and citizen monitoring groups throughout the Central Valley Region were contacted to assist in site selection and field sample collection. The following nineteen stakeholder groups assisted with the site selection process: American Basin Council of Watersheds, American River Watershed Group, Big Chico Creek Alliance, Butte Creek Watershed Conservancy, Cottonwood Creek Watershed Group, Deer Creek Conservancy, Ebbetts Pass Forest Watch, Feather River Coordinated Resource Management, Friends of Deer Creek, Friends of the South Fork Kings River, Merced River Alliance, Pit River Alliance, RiverTree Volunteers, Sacramento River Watershed Program, South Fork American River Watershed Group, South Yuba River Citizens League, Tuolumne River Trust, Upper Sacramento River Exchange and the Western Shasta Resource Conservation District. Several sites identified by the Upper Mokelumne River Watershed Council and the Tuolumne County Citizen Monitor Group for the 2007 pilot study were re-sampled for this study. The following five stakeholder groups were also able to participate in the study collecting samples and taking field measurements: American Basin Council of Watersheds (ABCW), Ebbetts Pass Forest Watch (EPFW), Friends of Deer Creek (FODC), RiverTree Volunteers, and South Yuba River Citizens League (SYRCL). In total, 17 sites were sampled by citizen groups and 40 sites were sampled by Regional Board staff.

Citizen monitors and Central Valley Water Board staff were provided sample collection procedures and training, developed by the Central Valley Water Board staff. Sample collection field sheets, bacteria processing worksheets, and sample collection bottles were also provided by the Central Valley Water Board

staff. *E. coli* analysis was conducted in-house by the Central Valley Water Board staff, using EPA's Standard Method 9223B (IDEXX Colilert ® QuantiTray system). Seven field crews from Central Valley Water Board were required for each sample collection date. Field measurements included temperature, pH and specific conductivity. In addition, photographs were taken of the swimming holes at each sampling event.

As recommended in the pilot study (Central Valley Water Board, 2009), samples were collected primarily between 11am and 4 pm on each sampling day in an effort to capture water conditions during the time of day when recreation is highest, while still allowing enough time to transfer samples from citizen groups and begin sample processing the same day as collection.

Table 1 provides a description of each location and the group responsible for sample collection. Map 1 displays the selected sample sites throughout the entire Central Valley Region (sites are numbered to correspond with the listing in Table 1). There were a total of 57 sampling sites.

Table 1. Safe-to-Swim Study, Labor Day 2008 - Sample Site Summary

No.	Watershed	County	SWAMP Site Code	Site Description	Samples Collected By
1	American River	Placer	514AMR800	American River, North Fork, @ Yankee Jims Road	Central Valley Water Board-S
2	American River	Placer	514AMR801	American River, North Fork @ Ponderosa Way	Central Valley Water Board-S
3	American River	Placer	514AMR802	American River, North Fork at Confluence with Middle Fork	Central Valley Water Board-S
4	American River	Placer	514AMR803	American River, Middle Fork @ Driver's Flat	Central Valley Water Board-S
5	American River	Placer	514AMR804	American River, Middle Fork @ Mammoth Bar	Central Valley Water Board-S
6	American River	El Dorado	514AMR805	American River, South Fork @ Lotus	Central Valley Water Board-S
7	American River	El Dorado	514AMR806	American River, South Fork @ Kyburz	Central Valley Water Board-S
8	American River	El Dorado	514AMR807	American River, Silver Fork @ China Flat campground	Central Valley Water Board-S
9	American River	El Dorado	514AMR807	American River, Silver Fork @ China Flat campground; DAY USE AREA	Central Valley Water Board-S
10	American River	El Dorado	514AMR808	American River, South Fork @ Salmon Falls Road	Central Valley Water Board-R
11	American River	Sacramento	544SAC007	American River at Discovery Park	Central Valley Water Board-S
12	American River	Sacramento	544SAC008	American River at Sunrise	Central Valley Water Board-S
13	Big Chico Creek	Butte	520BUT901	Big Chico Creek @ Bidwell Park below swimming pool	Central Valley Water Board-R
14	Butte Creek	Butte	520BUT900	Butte Creek @ Honey Run Bridge	Central Valley Water Board-R
15	Calaveras	Calaveras	533CAL900	Upper San Antonio Crk @ in-flow of White Pines Lake	EPFW
16	Calaveras	Calaveras	533CAL901	Upper San Antonio Crk @ out-flow of White Pines Lake	EPFW
17	Clear Creek	Shasta	508SHA903	Clear Creek @ SHY 273 bridge	Central Valley Water Board-R
18	Clear Creek	Shasta	508SHA904	Clear Creek @ SHY 299 bridge	Central Valley Water Board-R
19	Cosumnes	El Dorado	532ELD003	Cosumnes River at Gold Beach	Central Valley Water Board-S

Table 1 (cont.). Safe-to-Swim Study, Labor Day 2008 - Sample Site Summary

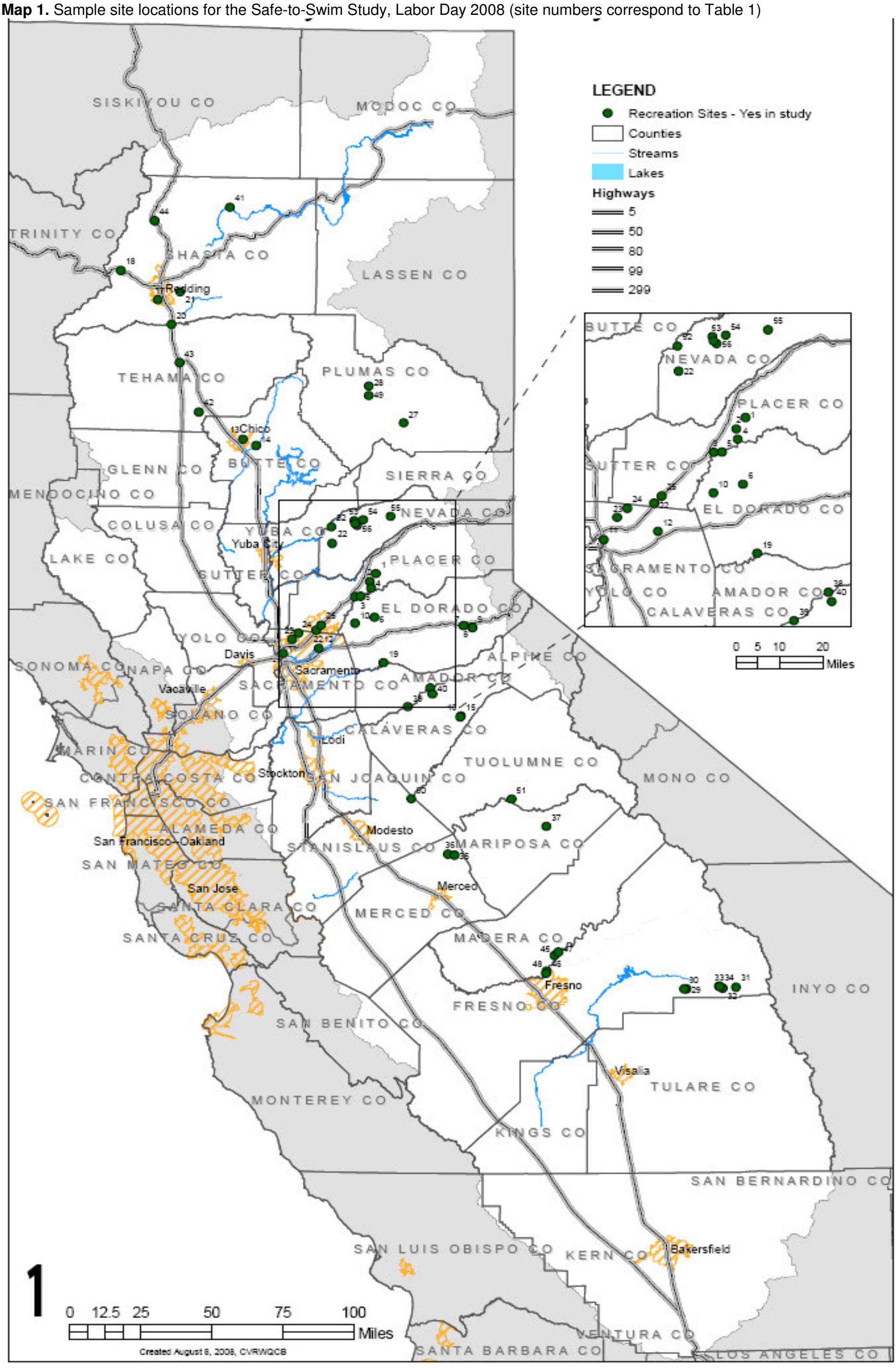
No.	Watershed	County	SWAMP Site Code	Site Description	Samples Collected By
20	Cottonwood Creek	Shasta	508SHA900	Cottonwood Creek @ Interstate 5 bridge	Central Valley Water Board-R
21	Cow Creek	Shasta	508SHA902	Cow Creek @ SHY 44 bridge	Central Valley Water Board-R
22	Deer Creek	Nevada	516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	FODC
23	Dry Creek	Placer	531PLA900	Dry Creek/ Cirby Creek confluence	ABCW
24	Dry Creek	Placer	531PLA901	Dry Creek @ Walerga Bridge	ABCW
25	Dry Creek	Placer	531PLA902	Miners Ravine/Secret Ravine Confluence	ABCW
26	Dry Creek	Sacramento	531SAC900	Dry Creek @ Hayer Dam	ABCW
27	Feather River - Middle Fork	Plumas	518PLU901	Feather River, Middle Fork @ Sloat	Central Valley Water Board-R
28	Indian Creek	Plumas	518INABSP	Indian Falls near HWY 89	Central Valley Water Board-R
29	Kings River	Fresno	552HUM020	Ten Mile Creek @ Hume Lake	Central Valley Water Board-F
30	Kings River	Fresno	552HUM030	Long Meadow Creek @ Hume Lake	Central Valley Water Board-F
31	Kings River	Fresno	552KIN900	Kings River, South Fork @ Muir Rock and Hwy 180	Central Valley Water Board-F
32	Kings River	Fresno	552KIN901	Kings River, South Fork @ Hotel Creek and Cedar Grove	Central Valley Water Board-F
33	Kings River	Fresno	552KIN902	Kings River, South Fork@ Lewis Creek Trailhead	Central Valley Water Board-F
34	Kings River	Fresno	552KIN903	Kings River, South Fork @ 180 & Cedar Grove	Central Valley Water Board-F
35	Merced	Merced	535MER209	Merced River at Merced Falls	Central Valley Water Board-S
36	Merced	Merced	535MER210	Merced River at Henderson Park	Central Valley Water Board-S
37	Merced	Merced	537MAR900	Merced River at El Portal-“Patty’s Hole”	Central Valley Water Board-S
38	Mokelumne	Amador	532AMA001	Mokelumne River, North Fork, at Hwy 26 Bridge	Central Valley Water Board-S
39	Mokelumne	Amador	532AMA005	Mokelumne River below Box Beach	Central Valley Water Board-S
40	Mokelumne	Calaveras	533CAL009	Mokelumne River, Middle Fork, at Hwy 26 Bridge	Central Valley Water Board-S
41	Pit River	Shasta	506SHA950	Pit River @ Big Bend	Central Valley Water Board-R

Table 1 (cont.). Safe-to-Swim Study, Labor Day 2008 - Sample Site Summary

No.	Watershed	County	SWAMP Site Code	Site Description	Samples Collected By
42	Sacramento River - Lower	Shasta	508SHA901	Sacramento River, Lower @ Anderson, Woodson Bridge Boat Ramp	Central Valley Water Board-R
43	Sacramento River - Upper	Tehama	504TEH900	Sacramento River, Upper @ Red Bluff, east end of Willow Street	Central Valley Water Board-R
44	Sacramento River - Upper	Shasta	506SHA951	Sacramento River, Upper @ Dog Creek confluence	Central Valley Water Board-R
45	San Joaquin	Fresno	545FRE502	San Joaquin River @ Lost Lake County Park	RT
46	San Joaquin	Fresno	545FRE503	San Joaquin River @ Fort Washington Beach	RT
47	San Joaquin	Fresno	545FRE504	San Joaquin River @ Friant Cove	RT
48	San Joaquin	Madera	545MAD008	San Joaquin River @ Wildwood Native park	RT
49	Spanish Creek	Plumas	518PLU900	Spanish Creek @ USFS campground off HWY 70	Central Valley Water Board-R
50	Stanislaus	Stanislaus	535STC201	Stanislaus River @ Knight's Ferry	Central Valley Water Board-S
51	Tuolumne	Tuolumne	536TUO900	Tuolumne River, South Fork @ Rainbow Pools	Central Valley Water Board-S
52	Yuba	Nevada	516NEV900	South Yuba River at Bridgeport	SYRCL
53	Yuba	Nevada	516NEV901	South Yuba River at Purdon crossing	SYRCL
54	Yuba	Nevada	516NEV902	South Yuba River at Edwards Crossing	SYRCL
55	Yuba	Nevada	516NEV903	South Yuba River Below Washington	SYRCL
56	Yuba	Nevada	516NEV904	Rock Creek Below Lake Vera, below Dam	SYRCL
57	Yuba	Nevada	516NEV905	Rock Creek Below Lake Vera, near Yuba	SYRCL

Central Valley Water Board-S = staff from the Central Valley Regional Water Quality Control Board – Sacramento Office
Central Valley Water Board-R = staff from the Central Valley Regional Water Quality Control Board – Redding Office
Central Valley Water Board-F = staff from the Central Valley Regional Water Quality Control Board – Fresno Office
ABCW = American Basin Council of Watersheds
EPFW = Ebbetts Pass Forest Watch
FODC = Friends of Deer Creek
RT = RiverTree Volunteers
SYRCL = South Yuba River Citizens League

Map 1. Sample site locations for the Safe-to-Swim Study, Labor Day 2008 (site numbers correspond to Table 1)



5.0 QUALITY ASSURANCE AND QUALITY CONTROL

Procedures for bacterial sample preparation, collection and analysis were based on the San Joaquin River Basin Bacteria Monitoring Procedures Manual (Central Valley Water Board, 2008a). Collection and analysis of all water samples occurred in compliance with the Quality Assurance Project Plan for this project (Central Valley Water Board, 2008b).

Samples collected for *E. coli* were analyzed using the IDEXX® Colilert-18 method (Analytical methods 9223B in STANDARD METHODS, EDITION 20). Results using the Colilert method are reported in terms of Most Probably Number (MPN). Analyses were conducted in the Central Valley Regional Water Quality Control Board laboratories. The QA/QC logs for bacteria analysis are found in the Central Valley Water Board laboratory where samples are analyzed.

Field and handling contamination were evaluated by submitting blind travel blanks (phosphate buffered saline) on each run for bacteria monitoring. Travel blank samples traveled through the sampling run, and were processed with the sample set. Blind laboratory blanks (phosphate buffered saline) were also used in each laboratory on each sampling day. All data sets used for this report had travel and laboratory blank results that fell below the analytical detection limits for the elements of concern.

Sample site homogeneity was evaluated by collecting and analyzing replicate bacteria samples at a 10% frequency for each sampling event.

Lab precision and accuracy were evaluated using blind split field samples. Blind split samples were collected at a 10% frequency for each sampling event by collecting the sample in a container double the normal sample volume and splitting that sample into two equal amounts for submittal to the analyzing laboratory.

Field measurements included temperature, pH, and specific conductivity (SC), and were collected using one of the following meters: a Yellow Springs Instruments (YSI) Sonde Model 6920 and YSI Logger Model 650 MDS, a YSI 63 multiparameter meter, a Myron 6P Ultra Meter II, a Hanna HI98127 pHep4 Tester (pH/temperature only), or an Oakton TDS ECTTestr3 35661-32 (conductivity only).

Table 2 lists the reporting limits, holding times and acceptable recoveries for the parameters monitored. Only data from sample sets whose QA/QC met these specifications have been included in this report.

Table 2. Parameters, Acceptable Analytical Recoveries, Reporting Limits, and Holding Times

Group	Parameter	Recovery	Target Reporting Limits	Completeness	Holding Time	Container
Field Analyses						
	pH by meter	NA	NA	NA	NA	NA
	Conductivity	NA	NA	NA	NA	NA
	Temperature	NA	NA	NA	NA	NA
Laboratory Analyses						
Bacterial Analyses	E. coli	95% Confidence Interval	2 MPN/100 mL	95%	24 Hr	Factory sterilized 100 ml plastic
Bacterial Analyses	Total Coliform	95% Confidence Interval	2 MPN/100 mL	95%	24 Hr	Factory sterilized 100 ml plastic

6.0 RESULTS

Water Quality Objective

The Central Valley Regional Water Quality Control Board (Central Valley Water Board) Basin Plan identifies contact recreation as a beneficial use throughout the Region. The U.S. EPA has developed contact recreation guidelines for *E. coli,* as described in Table 3. This study utilized the swimming level of contact at <235 MPN/100mL as the water quality threshold to indicate a potential concern.

Table 3. U.S. EPA contact recreation guidelines for *E. coli*

Level of Contact	USEPA E. coli Guideline (MPN/100ml)
Designated beach area	<235
Moderate full body contact	<298
Light full body contact	<409
Infrequent full body contact	<574

Table 4 below displays the *E. coli* concentrations for each site before (08/27/2008), during (08/31/2008) and after (09/03/2008) the Labor Day weekend.

Table 4. *E. coli* concentrations (MPN/100mL) for each site on 08/27/2008, 08/31/2008 and 09/03/2008

SWAMP Site Code	Site Description	E. coli (MPN/100 ml)		
		08/27/08	08/31/08	09/03/08
514AMR800	American River, North Fork, @ Yankee Jims Road	<1.0	<1.0	1
514AMR801	American River, North Fork @ Ponderosa Way	4.1	<1.0	1
514AMR802	American River, North Fork at Confluence with Middle Fork,	4.1	<1.0	8.6
514AMR803	American River, Middle Fork @ Driver's Flat	5.2	5.2	2
514AMR804	American River, Middle Fork @ Mammoth Bar	2	2	1
514AMR805	American River, South Fork @ Lotus;	108.1	109.2	6.3
514AMR806	American River, South Fork @ Kyburz	<1.0	1	<1.0
514AMR807	American River, Silver Fork @ China Flat campground	2	27.9	3.1

Table 4 (cont.). *E. coli* concentrations (MPN/100mL) for each site on 08/27/2008, 08/31/2008 and 09/03/2008

SWAMP Site Code	Site Description	E. coli (MPN/100 ml)		
		08/27/08	08/31/08	09/03/08
514AMR807	American River, Silver Fork @ China Flat campground; DAY USE AREA	<1.0	7.4	<1.0
514AMR808	American River, South Fork @ Salmon Falls Road	33.6	14.6	8.4
544SAC007	American River at Discovery Park	1413.6[a]	275.5[a]	187.2
544SAC008	American River at Sunrise	28.8	14.8	21.8
520BUT901	Big Chico Creek @ Bidwell Park below swimming pool	46.5	48.8	81.6
520BUT900	Butte Creek @ Honey Run Bridge	35.9	43.2	41.4
533CAL900	Upper San Antonio Crk @ in-flow of White Pines Lake	12	30	5.2
533CAL901	Upper San Antonio Crk @ out-flow of White Pines Lake	8.5	56.5	7.5
508SHA903	Clear Creek @ SHY 273 bridge	14.5	25.6	12
508SHA904	Clear Creek @ SHY 299 bridge	27.5	113.7	39.9
532ELD003	Cosumnes River at Gold Beach	7.4	32	23.5
508SHA900	Cottonwood Creek @ Interstate 5 bridge	29.2	53.7	79.4
508SHA902	Cow Creek @ SHY 44 bridge	68.3	131.4	75.9
516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	228.2[b]	214.2	108.1
531PLA900	Dry Creek/ Cirby Creek confluence	2419.6[a]	209.8	272.3[a]
531PLA901	Dry Creek @ Walerga Bridge	290.9[a]	54.5	63.1
531PLA902	Miners Ravine/Secret Ravine Confluence	83.3	31.8	61.3
531SAC900	Dry Creek @ Hayer Dam	117.8	43.2	60.5
518PLU901	Feather River, Middle Fork @ Sloat	1	1	8.6
518INABSP	Indian Falls near HWY 89	2	<1	4.1
552HUM020	Ten Mile Creek @ Hume Lake	1	14.4	23.8
552HUM030	Long Meadow Creek @ Hume Lake	8.6	1	32.7

Table 4 (cont.). *E. coli* concentrations (MPN/100mL) for each site on 08/27/2008, 08/31/2008 and 09/03/2008

SWAMP Site Code	Site Description	E. coli (MPN/100 ml)		
		08/27/08	08/31/08	09/03/08
552KIN900	Kings River, South Fork @ Muir Rock and Hwy 180	1	3.1	8.5
552KIN901	Kings River, South Fork @ Hotel Creek and Cedar Grove	1	4.1	1
552KIN902	Kings River, South Fork@ Lewis Creek Trailhead	1	7.4	8.5
552KIN903	Kings River, South Fork @ 180 & Cedar Grove	3.1	3.1	4.1
535MER209	Merced River at Merced Falls	7.5	9.6	7.2
535MER210	Merced River at Henderson Park	8.5	62	19.9
537MAR900	Merced River at El Portal- “Patty’s Hole”	1	125.9	8.5
532AMA001	Mokelumne River, North Fork, at Hwy 26 Bridge	1	3.1	1
532AMA005	Mokelumne River below Box Beach	13.2	4.1	<1.0
533CAL009	Mokelumne River, Middle Fork, at Hwy 26 Bridge	88.2	148.3	124.6
506SHA950	Pit River @ Big Bend	18.7	10.9	6.2
508SHA901	Sacramento River, Lower @ Anderson, Woodson Bridge Boat Ramp	7.5	63.3	4.1
504TEH900	Sacramento River, Upper @ Red Bluff, east end of Willow Street	No sample collected	26.6	21.1
506SHA951	Sacramento River, Upper @ Dog Creek confluence	1	4.1	2
545FRE502	San Joaquin River @ Lost Lake County Park	14.2	8.5	13.4
545FRE503	San Joaquin River @ Fort Washington Beach	6.2	7.4	9.7
545FRE504	San Joaquin River @ Friant Cove	2	2	1
545MAD008	San Joaquin River @ Wildwood Native park	4.1	4.1	8.5
518PLU900	Spanish Creek @ USFS campground off HWY 70	20.1	18.9	10.9

Table 4 (cont.). *E. coli* concentrations (MPN/100mL) for each site on 08/27/2008, 08/31/2008 and 09/03/2008

SWAMP Site Code	Site Description	E. coli (MPN/100 ml)		
535STC201	Stanislaus River @ Knight's Ferry	56.5	9.7	13.5
536TUO900	SF Tuolumne River @ Rainbow Pools	6.3	11	13.5
516NEV900	South Yuba River at Bridgeport	3	3.1	6.3
516NEV901	South Yuba River at Purdon crossing	<1.0	2	290.9[a]
516NEV902	South Yuba River at Edwards Crossing	5.2	7.4	4.1
516NEV903	South Yuba River Below Washington	3.1	7.4	3.1
516NEV904	Rock Creek Below Lake Vera, below Dam	18.9	14.6	6.3
516NEV905	Rock Creek Below Lake Vera, near Yuba	41.4	5.2	25.9

[a] *E. coli* values exceed the EPA guideline of 235 MPN/100mL

[b] A duplicate Quality Assurance field sample at this site exceeded the EPA guideline with a value of 260.3 MPN/100mL

Table 5 contains the data for specific conductivity, pH and temperature for each site.

Table 5. Specific conductivity, pH and temperature data for each site on 08/27/08, 08/31/08 and 09/03/08.

SWAMP Site Code	Site Description	Specific conductivity (umhos/cm)			pH			Temperature (º Celsius)		
		08/27/08	08/31/08	09/03/08	08/27/08	08/31/08	09/03/08	08/27/08	08/31/08	09/03/08
514AMR800	American River, North Fork, @ Yankee Jims Road	142.1	141.9	n/a	8.7	6.54	n/a	26.6	24.1	23.3
514AMR801	American River, North Fork @ Ponderosa Way	138.7	143	n/a	8.84	6.73	n/a	27.8	23.6	22.8
514AMR802	American River, North Fork at Confluence with Middle Fork,	133	116	110.5	8.5	6.67	6.55	25.63	23.3	22.5
514AMR803	American River, Middle Fork @ Driver's Flat	34.6	38	37.11	8.82	6.98	5.1	17.8	17	14.4
514AMR804	American River, Middle Fork @ Mammoth Bar	39.55	40	37.43	9.08	7.11	5.41	20.8	18.8	18.4
514AMR805	American River, South Fork @ Lotus;	23	21	22	7.49	8.00	8.21	16.59	14.59	14.95
514AMR806	American River, South Fork @ Kyburz	32	30	32	7.49	7.72	8.18	19.77	17.21	16.48
514AMR807	American River, Silver Fork @ China Flat campground	27	25	25	7.39	7.82	7.99	18.94	16.5	15.44
514AMR807	American River, Silver Fork @ China Flat campground; DAY USE AREA	27	26	21	7.43	7.6	7.74	18.85	16.43	15.44
514AMR808	American River, South Fork @ Salmon Falls Road	24	24	25	7.85	8.09	8.51	15.38	17.26	15.56
544SAC007	American River at Discovery Park	386.5	48.1	59.2	9.55	7.7	7.47	21.4	20.5	21.2
544SAC008	American River at Sunrise	58	57	60	7.43	8.12	8.02	20.73	21.68	21.65

Table 5 (cont.) Specific conductivity, pH and temperature data for each site on 08/27/08, 08/31/08 and 09/03/08.

SWAMP Site Code	Site Description	Specific conductivity (umhos/cm)			pH			Temperature (º Celsius)		
		08/27/08	08/31/08	09/03/08	08/27/08	08/31/08	09/03/08	08/27/08	08/31/08	09/03/08
520BUT901	Big Chico Creek @ Bidwell Park below swimming pool	n/a	230	n/a	n/a	7.4	n/a	n/a	23.3	n/a
520BUT900	Butte Creek @ Honey Run Bridge	n/a	113.5	n/a	n/a	8.5	n/a	n/a	20.8	n/a
533CAL900	Upper San Antonio Crk @ in-flow of White Pines Lake	62	50	62	7.53	7.00	7.75	14.7	13.4	12.0
533CAL901	Upper San Antonio Crk @ out-flow of White Pines Lake	62	50	62	7.53	7.00	7.75	24.2	23.0	22.3
508SHA903	Clear Creek @ SHY 273 bridge	n/a	92.5	n/a	n/a	8.0	n/a	n/a	19.1	n/a
508SHA904	Clear Creek @ SHY 299 bridge	n/a	288	n/a	n/a	6.71	n/a	n/a	18.3	n/a
532ELD003	Cosumnes River at Gold Beach	66	66	66	7.21	6.85	7.6	25.01	23.83	22.4
508SHA900	Cottonwood Creek @ Interstate 5 bridge	n/a	212.1	n/a	n/a	7.12	n/a	n/a	21.4	n/a
508SHA902	Cow Creek @ SHY 44 bridge	n/a	211	n/a	n/a	7.01	n/a	n/a	19.5	n/a
516NEV906	Squirrel Creek in Western Gateway Park, Penn Valley	84.9	84.7	80.3	7.28	7.30	7.28	20.1	19.6	16.5
531PLA900	Dry Creek/ Cirby Creek confluence	100.3	104.0	103.4	7.65	7.57	7.50	23.1	21.5	21.5
531PLA901	Dry Creek @ Walerga Bridge	240.5	223.7	226.7	7.64	7.69	7.68	25.9	23.5	23.7
531PLA902	Miners Ravine/Secret Ravine Confluence	119.0	136.5	124.8	7.56	7.19	7.14	22.0	21.5	20.4

Table 5 (cont.). Specific conductivity, pH and temperature data for each site on 08/27/08, 08/31/08 and 09/03/08.

SWAMP Site Code	Site Description	Specific conductivity (umhos/cm)			pH			Temperature (º Celsius)		
		08/27/08	08/31/08	09/03/08	08/27/08	08/31/08	09/03/08	08/27/08	08/31/08	09/03/08
531SAC900	Dry Creek @ Hayer Dam	299.5	295.7	257.6	7.74	7.73	7.74	25.0	22.5	22.7
518PLU901	Feather River, Middle Fork @ Sloat	147.9	n/a	148.4	7.12	n/a	7.85	19.1	n/a	13.1
518INABSP	Indian Falls near HWY 89	220.8	n/a	224.5	7.61	n/a	7.68	21.4	n/a	15.1
552HUM020	Ten Mile Creek @ Hume Lake	44.2	44.7	44.0	8.40	8.00	7.31	24.7	23.1	21.7
552HUM030	Long Meadow Creek @ Hume Lake	73.5	76.8	75.3	6.45	6.45	6.40	21.4	19.5	18.1
552KIN900	Kings River, South Fork @ Muir Rock and Hwy 180	45.5	47.7	45.8	6.87	7.10	6.25	15.4	15.2	12.3
552KIN901	Kings River, South Fork @ Hotel Creek and Cedar Grove	45.0	46.6	47.6	6.74	7.00	6.80	18.0	16.7	14.2
552KIN902	Kings River, South Fork@ Lewis Creek Trailhead	47.9	49.8	50.5	7.00	7.07	7.08	19.1	17.0	14.5
552KIN903	Kings River, South Fork @ 180 & Cedar Grove	46.3	48.0	48.7	6.94	6.90	6.98	20.1	17.0	14.7
535MER209	Merced River at Merced Falls	25	25	26	7.88	8.06	7.84	19.11	17.65	17.89
535MER210	Merced River at Henderson Park	27	27	27	7.88	7.89	7.8	20.25	19.2	19.24
537MAR900	Merced River at El Portal-“Patty’s Hole”	42	43	35	8.33	8.11	7.7	24.3	21.95	20.62
532AMA001	Mokelumne River, North Fork, at Hwy 26 Bridge	22.52	33.6	21.28	9.33	8.04	7.42	16	15	17. 1

Table 5 (cont.). Specific conductivity, pH and temperature data for each site on 08/27/08, 08/31/08 and 09/03/08.

SWAMP Site Code	Site Description	Specific conductivity (umhos/cm)			pH			Temperature (º Celsius)		
		08/27/08	08/31/08	09/03/08	08/27/08	08/31/08	09/03/08	08/27/08	08/31/08	09/03/08
532AMA005	Mokelumne River below Box Beach	29.2	23	29.88	9.13	8.14	7.64	19.5	16.9	20.1
533CAL009	Mokelumne River, Middle Fork, at Hwy 26 Bridge	77.6	72.4	71.74	8.68	6.77	6.91	20.2	17.3	19.8
506SHA950	Pit River @ Big Bend	149.0	n/a	142.3	7.3	n/a	8.3	21.1	n/a	17.4
508SHA901	Sacramento River, Lower @ Anderson, Woodson Bridge Boat Ramp	n/a	127.5	n/a	n/a	7.95	n/a	n/a	18.5	n/a
504TEH900	Sacramento River, Upper @ Red Bluff, east end of Willow Street	n/a	121.5	n/a	n/a	7.50	n/a	n/a	18.4	n/a
506SHA951	Sacramento River, Upper @ Dog Creek confluence	n/a	150	n/a	n/a	7.58	n/a	n/a	15.3	n/a
545FRE502	San Joaquin River @ Lost Lake County Park	56.0	76.6	100.9	7.09	6.07	5.60	12	11.5	11
545FRE503	San Joaquin River @ Fort Washington Beach	57.1	57.9	58.0	6.87	6.54	6.27	19	19	17
545FRE504	San Joaquin River @ Friant Cove	54.0	54.7	54.4	6.78	6.57	6.37	12	11	11
545MAD008	San Joaquin River @ Wildwood Native park	54.6	54.7	53.9	7.10	6.56	6.43	21	20	19
518PLU900	Spanish Creek @ USFS campground off HWY 70	208.4	n/a	198.2	7.14	n/a	7.67	20.7	n/a	14.5
535STC201	Stanislaus River @ Knight's Ferry	59	53	58	7.79	8.01	8.26	14.03	14.23	14.15

Table 5 (cont.). Specific conductivity, pH and temperature data for each site on 08/27/08, 08/31/08 and 09/03/08.

SWAMP Site Code	Site Description	Specific conductivity (umhos/cm)			pH			Temperature (º Celsius)		
		08/27/08	08/31/08	09/03/08	08/27/08	08/31/08	09/03/08	08/27/08	08/31/08	09/03/08
536TUO900	SF Tuolumne River @ Rainbow Pools	83	85	87	8.01	7.73	7.53	20.59	19.13	16.44
516NEV900	South Yuba River at Bridgeport	120	130	120	7.3	7.6	7.5	25.0	23.7	20.7
516NEV901	South Yuba River at Purdon crossing	110	110	100	6.9	6.9	7.0	23.8	22.1	20.6
516NEV902	South Yuba River at Edwards Crossing	110	110	n/a	7.1	7.4	7.1	24.4	21.7	20.7
516NEV903	South Yuba River Below Washington	80	70	70	6.9	7.1	7.0	22.7	21.1	20.2
516NEV904	Rock Creek Below Lake Vera, below Dam	80	80	80	7.0	7.2	7.2	24.7	24.2	22.6
516NEV905	Rock Creek Below Lake Vera, near Yuba	90	10	10	7.6	7.7	7.7	20.1	18.8	18.0

Overall summary of results

Results show that 52 out of a total of 57 sites did not exceed the US EPA's recommended contact recreation limit for *E. coli* (>235 MPN/100mL) on any of the three collection dates. Four sites in the Sacramento River Basin exceeded the US EPA's recommended limit for *E. coli* on one or more of the collection dates. An additional site in the Sacramento River Basin (see Site 516NEV906) had a duplicate Quality Assurance field sample exceed the EPA guideline. Four of these 5 sites exhibited the highest *E. coli* concentrations on the first day of the study, before the Labor Day weekend. Total coliform was detected in all samples and *E. coli* concentrations were measured as a subset of the total coliform.

Water temperature was highest on the first day of the study at all but 5 of the sample sites. Nine of the sites did not have temperature measurements on the first day of the study. Much of the Central Valley Region experienced air temperatures >100 degrees Fahrenheit during the period of 08/27/2008 to 08/30/2008. A cooling trend lowered air temperature 10-20 degrees Fahrenheit in the Sacramento region on 08/31/2008, the second day of the study (NCDC/NOAA website- www7.ncdc.noaa.gov/CDO/cdo). Specific conductivity and pH varied at each location, but the majority of sites met the water quality guidelines for these constituents on all three days of the study. Summary sheets with field and *E. coli* data, photographs, and water quality guidelines are located in Appendix 1 and are also posted on: http://www.waterboards.ca.gov/centralvalley/water_issues/water_quality_studies/surface_water_ambient_monitoring/index.shtml

Discussion of Elevated E. coli Results

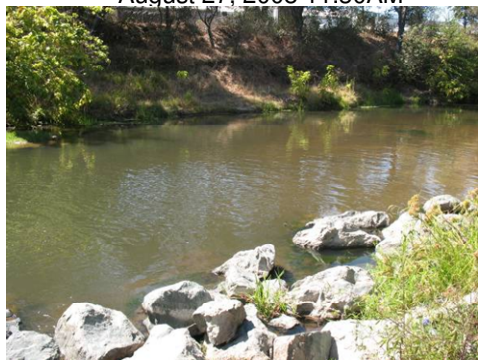
The five sites exhibiting elevated concentrations of *E. coli* are reviewed below by watershed.

Dry Creek Watershed – The highest *E. coli* levels were found in the Dry Creek Watershed located in Placer County. The Dry Creek watershed is one of the fastest urbanizing areas of California due to the extensive development of the Roseville region. Loss of riparian vegetation, stream bank erosion and sedimentation of streams are concerns expressed by the American Basin Council of Watersheds. Much of Dry Creek is also influenced by effluent discharged from Dry Creek Wastewater Treatment Plant (WWTP) in Roseville.

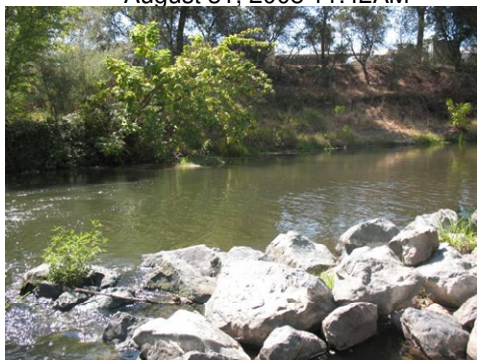
Two sites, the Dry Creek/Cirby Confluence (531PLA900) and Dry Creek at Walerga Bridge (531PLA901), had *E. coli* levels above 235 MPN/100mL. Figures 1 and 2 graphically display the data and provide photographs of the sites.

Figure 1. Data sheet for Dry Creek/Cirby Confluence (531PLA900)

August 27, 2008 11:30AM

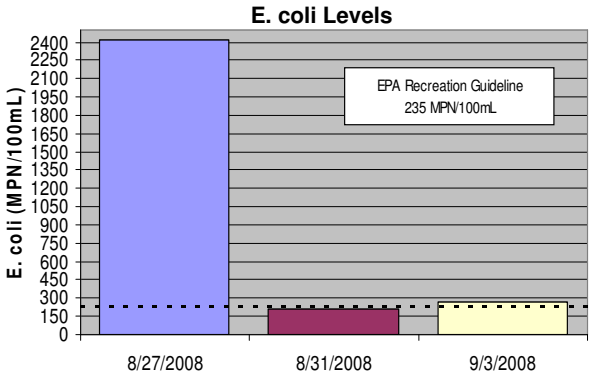


August 31, 2008 11:42AM



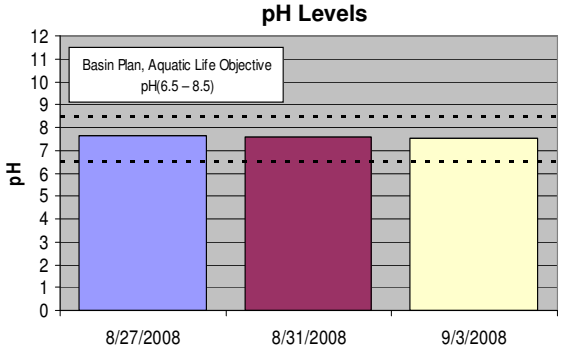
September 3, 2008 12:34PM

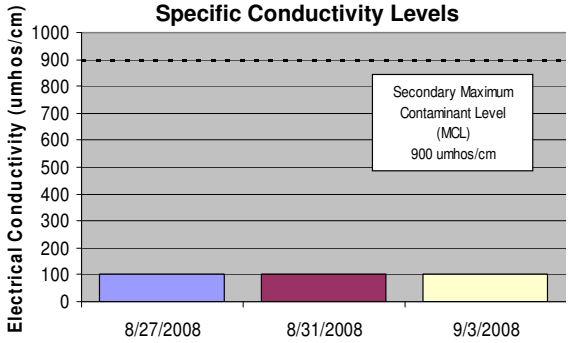
The Central Valley Regional Water Quality Control Board (CVRWQCB) conducted a region-wide Recreation Beneficial Use study, using *E. coli* as an indicator, with a guideline of 235 MPN/100mL. Funding for this study was made possible through the Surface Water Ambient Monitoring Program (SWAMP). Assistance with field collection was provided by a number of local watershed groups.

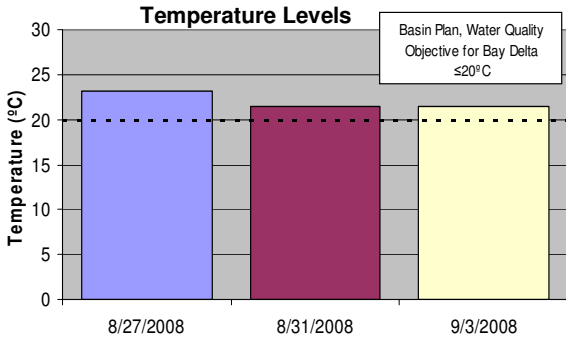


Summary sheets for all sites included in this study can be found at:

http://www.waterboards.ca.gov/centralvalley/water_issues/water_quality_studies/surface_water_ambient_monitoring/index.shtml



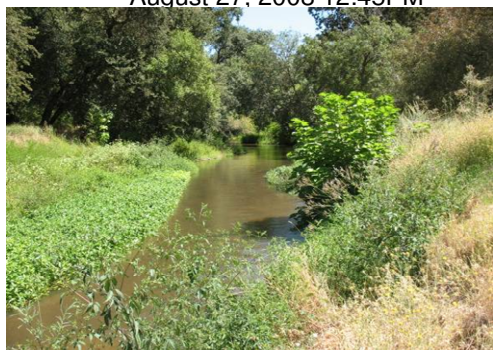




The American Basin Council of Watersheds (ABCW) assisted with field collection at this site

Figure 2. Data sheet for Dry Creek at Walerga Bridge (531PLA901)

August 27, 2008 12:45PM



August 31, 2008 12:13PM

September 3, 2008 12:55PM

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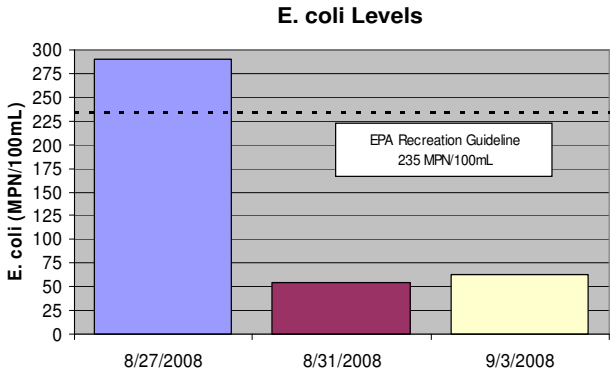

Summary sheets for all sites included in this study can be found at:

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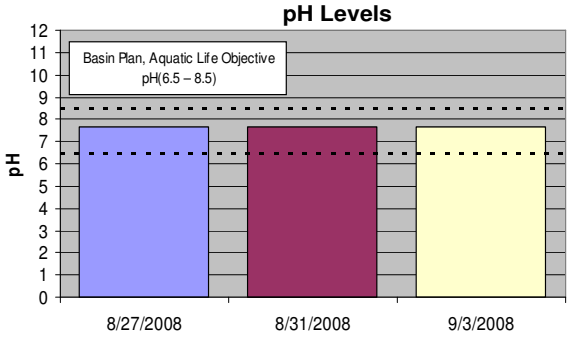
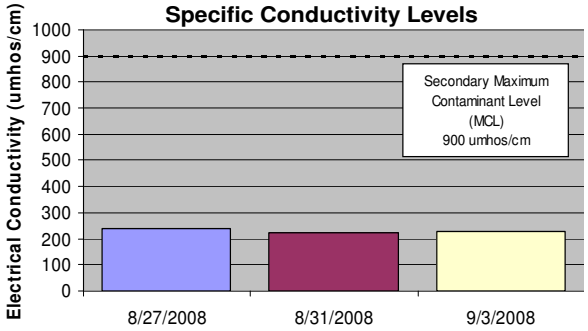
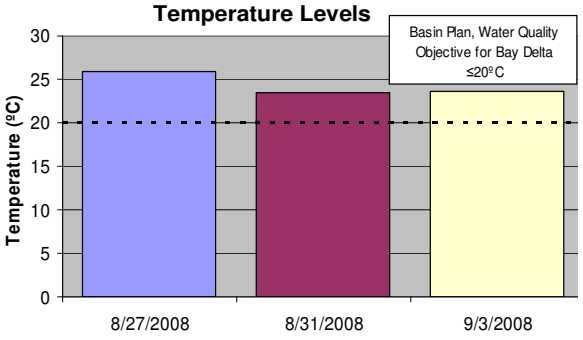






The American Basin Council of Watersheds (ABCW) assisted with field collection at this site

On 08/27/2008, the Dry Creek/Cirby Confluence site had a concentration of 2419.6 MPN/100mL *E. coli*, the upper reporting limit of the analytical method and greater than 10 times the US EPA guideline. *E. coli* levels at this site dropped on 08/31/2008 to 209.8 MPN/100mL but were above the guideline on 09/03/2008 at 272.3 MPN/100mL. An elevated concentration was also measured on 08/27/2008 at the Dry Creek at Walerga Bridge site with a value of 290.9 MPN/100mL. Subsequent measurements on 08/31/2008 and 09/03/2008 showed a drop in *E. coli* concentrations to 54.5 and 63.1 MPN/100mL, respectively.

The Dry Creek/Cirby Creek confluence site is located upstream of the WWTP and exhibited the highest levels of *E. coli*. The Dry Creek at Walerga site, followed by the Dry Creek at Hayer Dam site, is located downstream of the treatment plant. *E. coli* levels decrease with the addition of the treatment effluent.

SC and pH values met water quality guidelines and varied little during the study. Water temperature at both sites was approximately 2-degrees Celsius higher on the first day of the study as compared to the two following sample days. Flow data for this time period was not available for Dry Creek, but river stage data from the California Data Exchange Center website (http://cdec.water.ca.gov/) show little change over the course of the study for the following Dry Creek sites: Cirby Creek – Tina Way (site ID, CRB), Royer Park – Dry Creek (site ID, RYP) and Dry Creek at Veron Street Bridge (site ID, VRS).

Much of Dry Creek is surrounded by residential and commercial development. Photos taken during the study do not indicate heavy recreational use during the Labor Day period, although one photo shows people and a dog in the creek at the Hayer Dam site. The highest levels of *E. coli* were measured on the first day of the study – prior to the Labor Day weekend – indicating pre-holiday elevated *E. coli* concentration. Previous studies have shown that Cirby Creek and Dry Creek consistently contain concentrations above the guideline for *E. coli* (Dry Creek Conservancy, 2007).

American River Watershed - The American River is the second largest tributary to the Sacramento River. Ten sites were sampled along the North, Middle, and South Forks of the upper American River along with 2 sites in the lower watershed. One site in the lower watershed, American River at Discovery Park (544SAC007), had *E. coli* concentrations above the EPA guideline before and during the Labor Day weekend at 1413.6 MPN/100mL and 275.5 MPN/100mL, respectively. *E. coli* levels decreased to 187.2 MPN/100mL on the last day of the study.

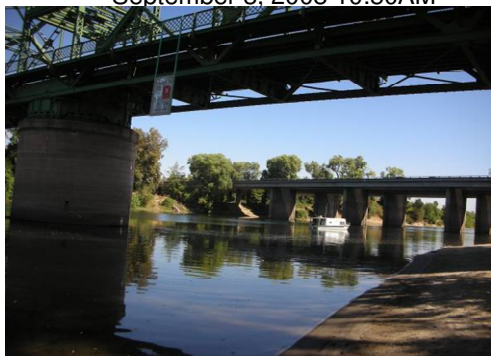
Discovery Park is a 302-acre park located in downtown Sacramento, where the lower American River meets the Sacramento River. This area is a popular recreational boating area. The flow in the lower American River is regulated at the Folsom Dam and Reservoir by the U.S. Bureau of Reclamation. Figure 3 graphically displays the data and provides photographs of this site.

Figure 3. Data sheet for American River at Discovery Park (544SAC007)

August 27, 2008 11:07AM

August 31, 2008 10:50AM

September 3, 2008 10:50AM



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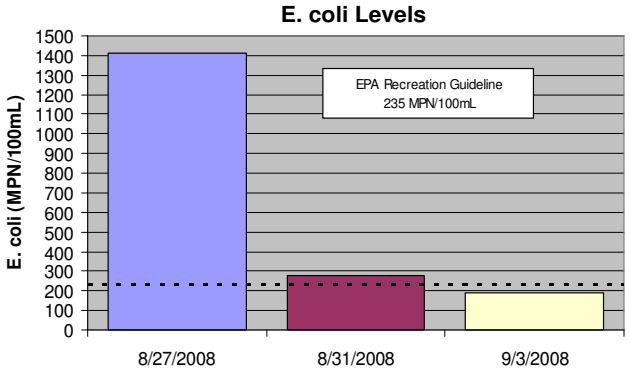
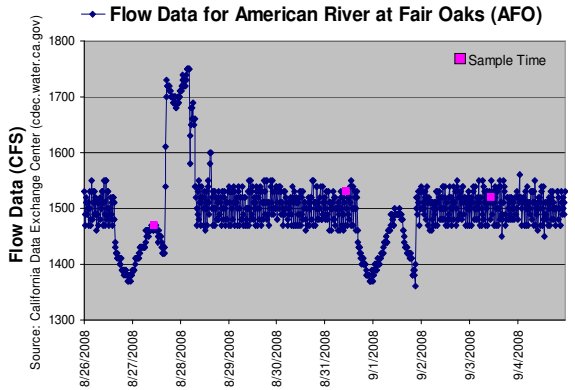
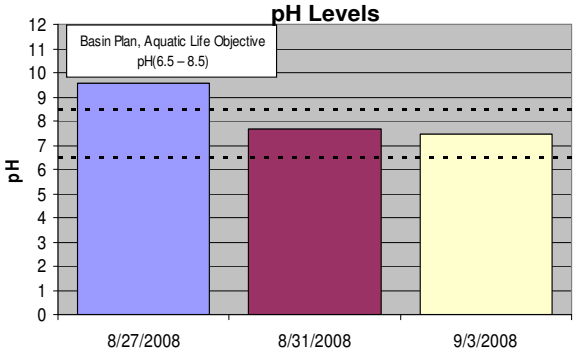
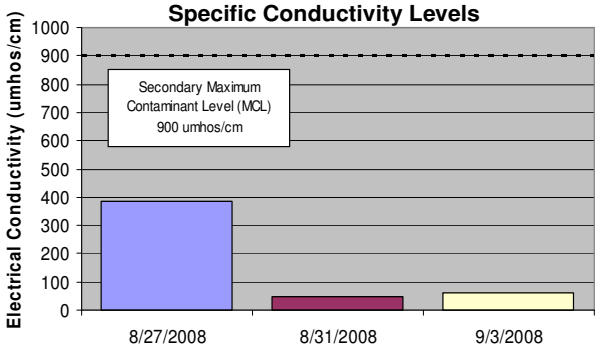
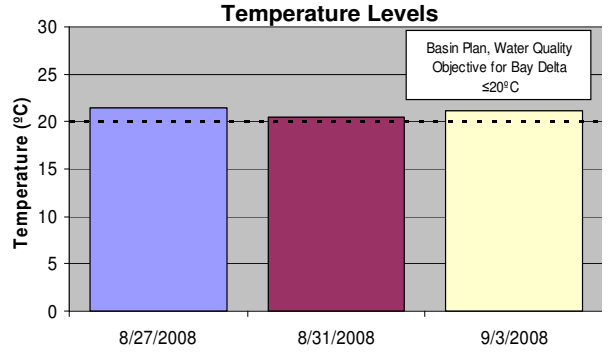










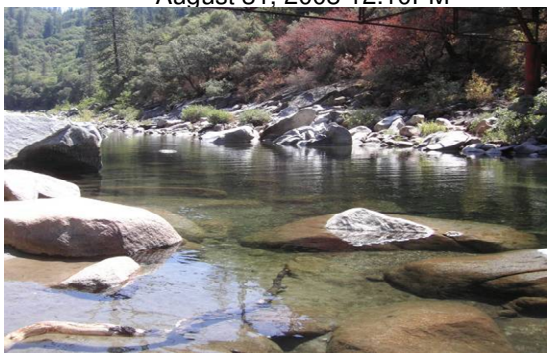
The pH level on the first day of the study was 9.55, which is an exceedance of the Central Valley Water Board Basin Plan Objective (ph levels should measure 6.5-8.5). The pH values on 08/31/2008 and 09/03/2008 were 7.7 and 7.47, respectively. Specific conductivity, although not above the Secondary Maximum Contaminant Level (900 umhos/cm), was also substantially higher on the first day of the study when *E. coli* values were highest (386.5 umhos/cm on 08/27/2008 compared to 48.1 and 59.2 umhos/cm on 08/31/2008 and 09/03/2008, respectively). Water temperature was comparable on all three days of the study. Flow data from the California Data Exchange Center website for the nearest station (American River at Fair Oaks, site ID AFO) measured at 1470 cfs at the time of sampling on the first day of the study. An increase in flow of at least 50 cfs was measured on the second and third day during sampling, with a significant flush of water occurring just prior to the weekend.

South Yuba River Watershed – The Yuba River is a major tributary of the Feather River, which is the largest tributary to the Sacramento River. The South Fork begins at Lake Spaulding and joins the other forks at Englebright Reservoir. Six swimming holes were selected and sampled by the South Yuba River Citizen's League (SYRCL). One site, South Yuba River at Purdon Crossing (516NEV901), had a concentration of *E. coli* greater than 235 MPN/100-ml on the last day of the study, following the Labor Day weekend. Figure 4 graphically displays the data and provides photographs of this site.

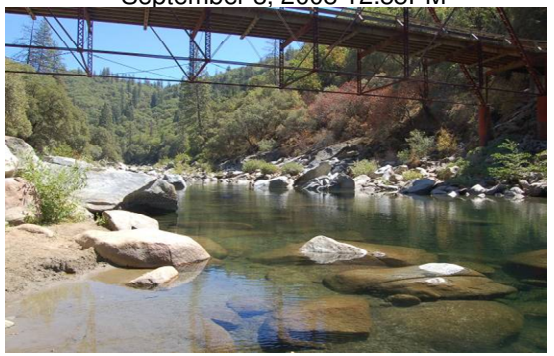
Figure 4. Data sheet for South Yuba River at Purdon Crossing (516NEV901)

August 27, 2008 13:10PM

August 31, 2008 12:10PM



September 3, 2008 12:55PM



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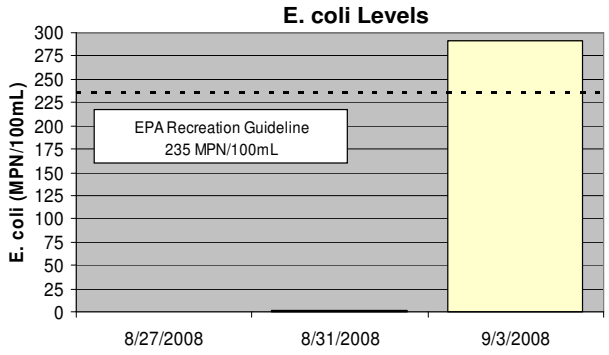
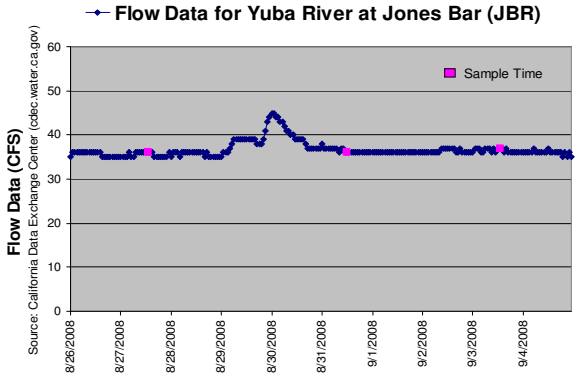
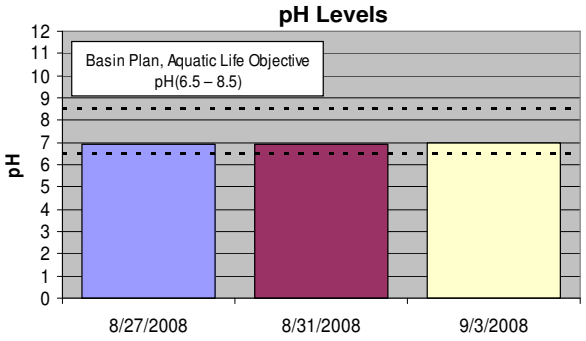
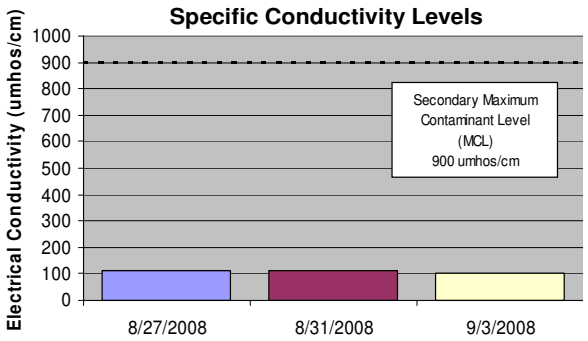
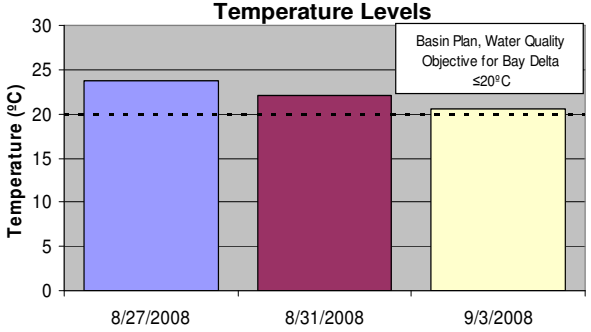










The South Yuba River Citizen's League (SYRCL) assisted with field collection at this site

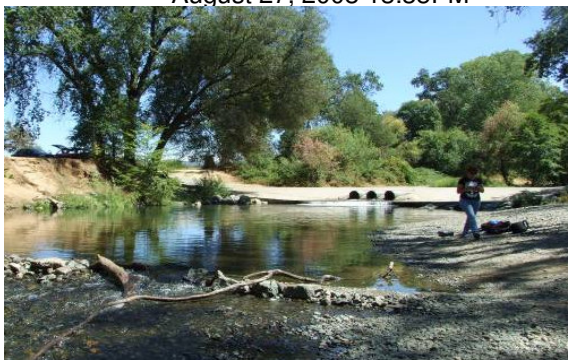
The site at Purdon Crossing is part of the South Yuba River State Park and is considered an access point to remote areas of the park. It is a popular hiking and fishing area. Unfortunately, there have been issues with illegal camping, drug use and general disrespect of the area as described by a representative of SYRCL (G. Reedy, personal communication, 12/18/2008). Incidence of human waste at this site has also been reported to SYRCL.

E. coli levels at Purdon Crossing were very low on the first two days of the study, measuring <1.0 MPN/100mL on 08/27/2008 and 2 MPN/100mL on 08/31/2008. The *E. coli* level increased on 09/03/2008 to 290.9 MPN/100mL. The pH and SC values met water quality guidelines and were comparable for all three days of the study. The water temperature decreased 3.2 degrees Celsius from the first to last day of the study. Flow data from the California Data Exchange Center website for the nearest station (Yuba River at Jones Bar, Station ID JBR) indicates little variation at the time of sampling on the three study days.

Deer Creek Watershed – Deer Creek is located in Nevada County and is a tributary of the Yuba River. The local stakeholder group, Friends of Deer Creek, selected and sampled one site for this study located in Squirrel Creek, a tributary to Deer Creek, at Western Gateway Park in Penn Valley (516NEV906). Western Gateway Park is a popular recreation spot and includes play structures, hiking trails, baseball fields and a community center. Photos show that this is a heavily used swimming area, especially over the Labor Day weekend. Figure 5 graphically displays the data and provides photographs of this site.

Figure 5. Data sheet for Squirrel Creek in Western Gateway Park, Penn Valley (516NEV906)

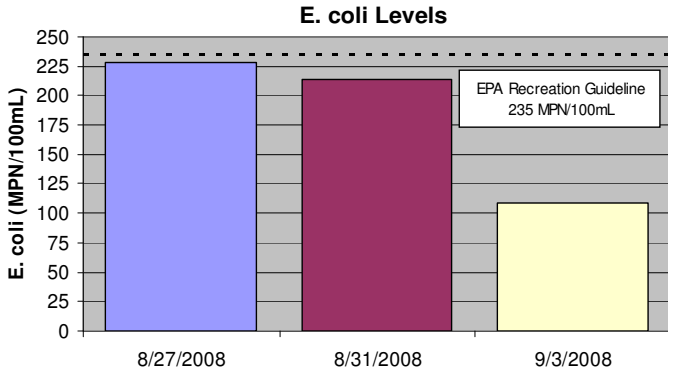
August 27, 2008 13:35PM



August 31, 2008 13:50PM

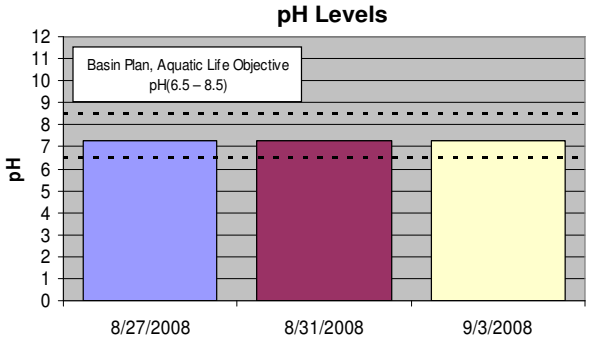
September 3, 2008 13:50PM

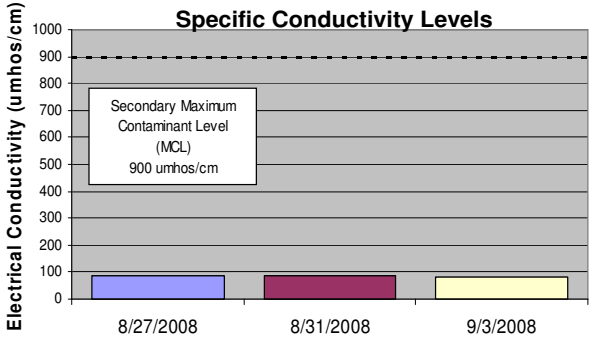
The Central Valley Regional Water Quality Control Board (CVRWQCB) conducted a region-wide Recreation Beneficial Use study, using *E. coli* as an indicator, with a guideline of 235 MPN/100mL. Funding for this study was made possible through the Surface Water Ambient Monitoring Program (SWAMP). Assistance with field collection was provided by a number of local watershed groups.

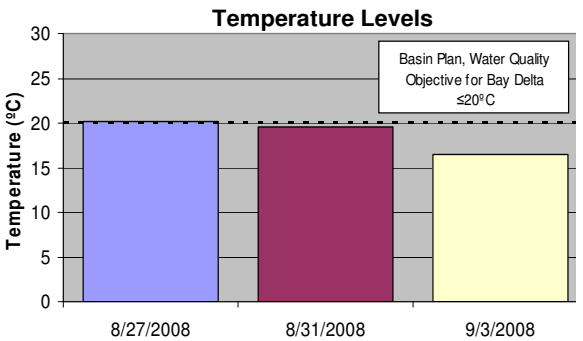


Summary sheets for all sites included in this study can be found at:

http://www.waterboards.ca.gov/centralvalley/water_issues/water_quality_studies/surface_water_ambient_monitoring/index.shtml







The Friends of Deer Creek assisted with field collection at this site

None of the normal grab samples for this site exceeded the EPA guideline of 235 MPN/100mL for *E. coli*. However, the *E. coli* concentrations for the first two days of the study were above 200 MPN/100mL. The duplicate QA field sample on 8/27/08 was above the EPA guideline with a value of 260.3 MPN/100mL. The normal sample had a statistically comparable value at 228.2 MPN/100mL. The pH and SC values met water quality guidelines and were comparable for all three days of the study. The water temperature decreased 3.6 degrees Celsius from the first to last day of the study. No flow data was available for Squirrel Creek.

In addition to the heavy human recreational use of Squirrel Creek during the holiday period, the Friends of Deer Creek indicated that cattle grazing may also influence the creek. There is an extensive grazing operation 1 mile directly upstream of the study site on Clear Creek. Cattle have been seen walking through the creek and using the creek for drinking water (J. Wood, personal communication, 1/27/2009). The Friends of Deer Creek have tested for *E. coli* both below and above this grazing site and found values to be high in both areas.

7.0 CONCLUSION

Fifty-two of the 57 sites selected for this study had *E. coli* concentrations below the US EPA contact recreation guideline (235 MPN/100 mL) before, during, and after Labor Day Weekend in 2008. The low *E. coli* concentrations suggest that swimmers at these sites may be at a reduced risk for pathogen exposure.

Four sites in the Sacramento River Basin did have concentrations above the US EPA's recommended limit for *E. coli* on one or more of the collection dates. An additional site in the Sacramento River Basin had a duplicate Quality Assurance field sample above the US EPA guideline. Four of these 5 sites exhibited the highest *E .coli* concentrations on the first day of the study, before the Labor Day weekend. Elevated *E. coli* concentrations prior to the highest level of human use indicate that factors other than human recreation likely dominate *E. coli* concentrations. Flow data and field measurements of temperature, SC and pH were variable between the 5 sites and it is unclear if these constituents had an effect on the *E. coli* concentrations.

Based on information collected during this project, future-monitoring efforts in the Central Valley Region should consider:

- Pathogen identification studies to help characterize *E. coli* sources.
- *E. coli O157:H7* analysis to determine if the pathogenic *E.coli* is present.
- Analysis for other types of water-borne pathogens like *Cryptosporidium* and *Giardia*.

- Follow-up *E. coli* sampling at other times of the year to develop a more thorough analysis of water quality.

8.0 REFERENCES

California Data Exchange Center website (http://cdec.water.ca.gov/).

Central Valley Water Board, 2008a. San Joaquin River Basin Bacteria Monitoring Procedures Manual. Central Valley Regional Water Quality Control Board, 55 pgs.

Central Valley Water Board, 2008b. Labor Day 2008 Recreational Use Study Monitoring Plan, Attachment 2, Quality Assurance Project Plan. Central Valley Regional Water Quality Control Board, 21 pgs.

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State Water Resources Control Board, 2002. SWAMP Quality Assurance Management Plan (QAMP) for the State of California's Surface Water Ambient Monitoring Program, 135 pgs., (http://www.swrcb.ca.gov/water_issues/programs/swamp/qamp.shtml).

State Water Resources Control Board, Clean Beaches/Oceans Program website (http://www.waterboards.ca.gov/water_issues/programs/beaches/beach_water_quality/index.shtml).